

WHAT IS CLAIMED IS:

1. A method for constructing a second finite element mesh within a first finite element mesh to model a second system within a first system modeled by said first mesh, comprising:
  - constructing said first mesh having a plurality of n-dimensional simplices corresponding to said first system;
  - defining a surface bounding said second system;
  - identifying a subset of the plurality of n-dimensional simplices of said first mesh that are intersected by said surface; and
  - modifying the identified subset of the plurality of n-dimensional simplices to adapt said first mesh such that it comprises said second mesh and a third mesh, wherein said second mesh comprises a first set of simplices located entirely interior to said surface and wherein said third mesh comprises a second set of simplices located entirely exterior to said surface.
2. The method of Claim 1, wherein modifying said identified subset of said plurality of n-dimensional simplices further comprises subdividing each of said simplices in said identified subset into a plurality of new simplices, and wherein a plurality of faces of said subdivided simplices are substantially coincident with said surface.
3. The method of Claim 1, wherein modifying said identified subset of the plurality of n-dimensional simplices comprises collapsing each of said simplices in said identified subset .
4. The method of Claim 3, wherein each of said n-dimensional simplices has a plurality of nodes and a plurality of edges connecting said nodes, wherein at least one of said nodes is invariant and wherein collapsing each of said simplices in said identified subset comprises removing one or more of said nodes, preventing removal of the invariant nodes, and forming simplices based upon the remaining nodes.
5. The method of Claim 1, wherein said first and said second systems are three-dimensional systems, wherein  $n=3$ , and wherein said surface is an  $(n-1)$ -dimensional surface.

6. The method of Claim 5, wherein said (n-1)-dimensional surface corresponds to a well bore surface, and wherein said (n-1)-dimensional surface is defined by a depth along a well bore trajectory and a radius from said well bore trajectory.
7. The method of Claim 1, wherein said first system is a reservoir.
8. The method of Claim 1, wherein said second system is a well bore.
9. The method of Claim 8, wherein said defining step further comprises providing a well bore trajectory, a radius from said trajectory, and a depth along said trajectory.
10. The method of Claim 1, wherein said step of constructing said first mesh is performed using a mesh generation algorithm.
11. The method of Claim 10, wherein said mesh generation algorithm is Inria.
12. The method of Claim 1, wherein each of the n-dimensional simplices in said identified subset of the plurality of n-dimensional simplices is intersected by an (n-1)-dimensional surface.
13. The method of Claim 12, wherein the (n-1)-dimensional surface intersects at least one edge of each of the n-dimensional simplices in the identified subset of the plurality of n-dimensional simplices.
14. The method of Claim 1, wherein each of said n-dimensional simplices has a plurality of nodes and a plurality of edges connecting said nodes, and wherein the method further comprises identifying intersections between the edges of said subset of simplices and said surface, defining a new node at each of said identified intersections, and defining at least two new simplices incorporating said new nodes.
15. The method of Claim 1, wherein said first system comprises a multi-level reservoir.

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19. A computer-readable medium containing a plurality of instructions embodying a method for constructing a second finite element mesh within a first finite element mesh to model a second system within a first system modeled by said first mesh, said method comprising:

constructing said first mesh having a plurality of n-dimensional simplices corresponding to said first system;  
defining a surface bounding said second system;  
identifying a subset of the plurality of n-dimensional simplices of said first mesh that are intersected by said surface; and  
modifying the identified subset of the plurality of n-dimensional simplices to adapt said first mesh such that it comprises said second mesh and a third mesh, wherein said second mesh comprises a first set of simplices located entirely interior to said surface and wherein said third mesh comprises a second set of simplices located entirely exterior to said surface.

20. The computer-readable medium of Claim 19, wherein said modifying step of said method further comprises subdividing each of said simplices in said identified subset into a plurality of new simplices, and wherein a plurality of faces of said subdivided simplices are substantially coincident with said surface.

21. The computer-readable medium of Claim 19, wherein said first and said second systems are three-dimensional systems, wherein  $n=3$ , and wherein said surface is an  $(n-1)$ -dimensional surface.

22. The computer-readable medium of Claim 21, wherein said  $(n-1)$ -dimensional surface corresponds to a well bore surface, and wherein said  $(n-1)$ -dimensional surface is defined by a depth along a well bore trajectory and a radius from said well bore trajectory.

23. The computer-readable medium of Claim 19, wherein said first system is a reservoir.

24. The computer-readable medium of Claim 19, wherein said second system is a well bore.

25. The computer-readable medium of Claim 24, wherein said defining step of said method further comprises providing a well bore trajectory, a radius from said trajectory, and a depth along said trajectory.

26. The computer-readable medium of Claim 19, wherein said step of constructing said first mesh of said method is performed using a mesh generation algorithm.

27. The computer-readable medium of Claim 26, wherein said mesh generation algorithm is Inria.

28. The computer-readable medium of Claim 19, wherein each of the n-dimensional simplices in said identified subset of the plurality of n-dimensional simplices is intersected by an (n-1)-dimensional surface.

29. The computer-readable medium of Claim 28, wherein the (n-1)-dimensional surface intersects at least one edge of each of said n-dimensional simplices in said identified subset of said plurality of n-dimensional simplices.

30. The computer-readable medium of Claim 19, wherein each of said n-dimensional simplices has a plurality of nodes and a plurality of edges connecting said nodes, and wherein said method further comprises identifying intersections between the edges of said subset of simplices and said surface, defining a new node at each of said identified intersections, and defining at least two new simplices incorporating said new nodes.

31. The computer-readable medium of Claim 19, wherein said first system comprises a multi-level reservoir.

32. The computer-readable medium of Claim 19, wherein said method further comprises the step of altering the value of system properties in said second mesh and in said third mesh near said second mesh to predict changes in system behavior for said second system.

33. A method for modeling a well bore in a three-dimensional reservoir, comprising:  
defining a plurality of two-dimensional boundaries of said reservoir;  
generating a two-dimensional surface triangulation mesh on one or more of said reservoir boundaries;  
defining said well bore within said reservoir, wherein said well bore comprises an isosurface within said reservoir;  
constructing a well-bore mesh, having a plurality of three-dimensional simplices, corresponding to said well bore, wherein a plurality of triangular faces of a subset of said simplices form a well bore surface triangulation and lie substantially coincident with said well bore isosurface; and  
constructing a reservoir mesh from said surface triangulation to fill said reservoir.
34. The method of Claim 33, wherein said constructing a reservoir mesh step further comprises preserving said surface triangulation on said reservoir boundaries and on said well bore isosurface.
35. The method of Claim 33, wherein said defining step further comprises providing a well bore trajectory, a radius from said trajectory, and a depth along said trajectory.
36. The method of Claim 33, wherein said step of constructing a well bore mesh and said step of constructing a reservoir mesh are performed using a mesh generation algorithm.
37. The method of Claim 36, wherein said mesh generation algorithm is Inria.
38. The method of Claim 33, wherein said reservoir is a multi-level reservoir.
39. The method of Claim 33, further comprising the step of altering the value of system properties in said second mesh and in said third mesh near said second mesh to predict changes in system behavior for said second system.
40. The method of Claim 33, wherein said method steps are performed on a computer.

41. The method of Claim 33, wherein said computer comprises a graphical user interface for inputting user instructions and parameter values.

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42. A computer-readable medium containing a plurality of instructions embodying a method for modeling a well bore in a three-dimensional reservoir, said method comprising:

defining a plurality of two-dimensional boundaries of said reservoir;

generating a two-dimensional surface triangulation mesh on one or more of said reservoir boundaries;

defining said well bore within said reservoir, wherein said well bore comprises an isosurface within said reservoir;

constructing a well-bore mesh, having a plurality of three-dimensional simplices, corresponding to said well bore, wherein a plurality of triangular faces of a subset of said simplices form a well bore surface triangulation and lie substantially coincident with said well bore isosurface; and

constructing a reservoir mesh from said surface triangulation to fill said reservoir.

43. The computer-readable medium of Claim 42, wherein said constructing a reservoir mesh step of said method further comprises preserving said surface triangulation on said reservoir boundaries and on said well bore isosurface.

44. The computer-readable medium of Claim 42, wherein said defining step of said method further comprises providing a well bore trajectory, a radius from said trajectory, and a depth along said trajectory.

45. The computer-readable medium of Claim 42, wherein said step of constructing a well bore mesh and said step of constructing a reservoir mesh of said method are performed using a mesh generation algorithm.

46. The computer-readable medium of Claim 45, wherein said mesh generation algorithm is Inria.

47. The computer-readable medium of Claim 42, wherein said reservoir is a multi-level reservoir.

48. The computer-readable medium of Claim 42, wherein said method further comprises the step of altering the value of system properties in said second mesh and in said third mesh near said second mesh to predict changes in system behavior for said second system.

49. The computer-readable medium of Claim 42, wherein said method steps are performed on a computer.

50. The computer-readable medium of Claim 49, wherein said computer comprises a graphical user interface for inputting user instructions and parameter values.

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